

## IT IS CLAIMED:

- 1        1. An ultrasonic etching apparatus for chemically-etching a workpiece, said  
2        apparatus comprising  
3                an outer tank at least partially filled with an aqueous solution;  
4                an inner tank comprising a chemically-resistant polymer and at least partially  
5        disposed within said outer tank and in contact with said aqueous solution, said inner  
6        tank at least partially filled with at least 1 liter of an etching solution having a total  
7        acidity or basicity of at least 10% wt, said inner tank having at least a sidewall and a  
8        base and defining an upper mouth, and being receptive to the workpiece;  
9                a lid engaged with said mouth of said inner tank, wherein the weight of the  
10      lid creates at least a partial seal between the mouth of said inner tank and a lower  
11      surface of said lid to increase the partial pressure of the gas above the etching  
12      solution; and  
13                an ultrasonic transducer coupled to said outer tank to impart ultrasonic  
14      energy to said etching solution in said inner tank.
- 1        2. The apparatus of claim 1, further comprising a heating element for  
2        regulating the temperature of the aqueous solution.
- 1        3. The apparatus of claim 1, further comprising a mechanism adapted to  
2        impart relative motion between the workpiece disposed in said inner tank and said  
3        ultrasonic transducer.
- 1        4. The apparatus of claim 3, wherein the mechanism comprises a rod  
2        extending through the lid and coupled to the workpiece.
- 1        5. The apparatus of claim 1, further comprising an exhaust hood which is  
2        located above the tanks and compatible with gases produced from at least one of  
3        the aqueous solution and the etching solution.
- 1        6. The apparatus of claim 1, further comprising an ultrasonic buffer  
2        positioned within the aqueous solution for dampening and/or diffusing the sonic  
3        energy imparted to the etching solution.
- 1        7. The apparatus of claim 1, wherein the ultrasonic transducer is positioned  
2        outside of the aqueous solution and is operably connected to a power oscillator.
- 1        8. The apparatus of claim 1, further comprising a probe positioned within

2 the etching solution for monitoring one or more of the ultrasonic energy,  
3 temperature, temperature variations and impurity concentration.

1           9. The apparatus of claim 1, wherein the aqueous solution is a filtered and  
2 recirculated deionized water bath.

1           10. The apparatus of claim 1, wherein the etching solution is essentially  
2 static.

1           11. The apparatus of claim 1, wherein the inner tank and any portion of the  
2 rotational mechanism that may come into contact with the etching solution  
3 comprises a material selected from the group consisting of a fluorine resin and high  
4 density polyethylene.

1           12. The apparatus of claim 11, wherein the inner tank generates less than  
2 10 ppb of leachable metal contaminants and 10 ppm of leachable anionic and  
3 organic contaminants.

1           13. The apparatus of claim 1, wherein the etching solution comprises an  
2 acid selected from the group consisting of hydrofluoric acid, nitric acid and  
3 hydrochloric acid.

1           14. The apparatus of claim 13, wherein the acidic solution comprises  
2 hydrofluoric acid, nitric acid and water in a ratio selected from the group consisting  
3 of 1:1:1, 1:2:2 and 1:7:4.

1           15. The apparatus of claim 1, wherein the temperature of the aqueous  
2 solution is maintained from about 20°C to about 50°C.

1           16. The apparatus of claim 1, wherein the workpiece is selected from the  
2 group consisting of silicon carbide, quartz, ceramic and silicon.

1           17. The apparatus of claim 3, wherein the mechanism comprises a rotary  
2 motion actuator for rotating said substrate about an axis.

1           18. The apparatus of claim 17, wherein the axis is a substantially horizontal  
2 axis.

1           19. The apparatus of claim 17, wherein the axis is a substantially vertical  
2 axis.

1           20. The apparatus of claim 3, wherein the mechanism comprises a rotary  
2 motion actuator for rotating said inner tank and/or said ultrasonic transducer.

1           21. The apparatus of claim 1, wherein the cross-section of the lid is  
2 substantially the same as the cross section of the mouth of the inner tank.

1           22. The apparatus of claim 21, wherein the mouth of the inner tank and the  
2 lid each have a circular shape corresponding to the cross-section of the lid.

1           23. The apparatus of claim 1, wherein the cross-section of the inner tank is  
2 substantially the same as the cross section of the workpiece.

1           24. The apparatus of claim 1, wherein the mouth of the inner tank has a  
2 shape selected from the group consisting of a square, rectangle, triangle, circle and  
3 oval.

1           25. The apparatus of claim 1, wherein the inner tank has a shape selected  
2 from the group consisting of a rectangular parallelepiped, cube and cylinder.

1           26. The apparatus of claim 1, wherein the etching solution comprises a  
2 base selected from the group consisting of sodium hydroxide and potassium  
3 hydroxide.

1           27. The apparatus of claim 26, wherein the etching solution comprises 30%  
2 potassium hydroxide.

1           28. A method for ultrasonically chemically-etching a workpiece, said  
2 method comprising  
3           providing an inner tank having an inner surface comprising a chemically-  
4 resistant polymer and defining an upper mouth and being receptive to the  
5 workpiece, wherein said inner tank is at least partially disposed within an outer tank  
6 at least partially filled with an aqueous solution;  
7           at least partially filling the inner tank with at least 1 liter of a etching solution  
8 having a total acidity or basicity of at least 10%;  
9           immersing the workpiece into the etching solution;  
10          covering the mouth of the inner tank with a lid to enclose the etching  
11 solution and to increase the partial pressure above the etching solution; and  
12          ultrasonically agitating the etching solution with an ultrasonic transducer

13      coupled to the outer tank to accelerate the etching of the workpiece.